NEW YORK ACADEMY OF SCIENCES.

November 7, 1881.

REGULAR BUSINESS MEETING.

The President, Dr. J. S. Newberry, in the Chair.

Twenty-nine persons present.

A paper by Prof. P. T. Cleve, University of Upsala, Sweden, was read, by Prof. D. S. Martin, entitled

OUTLINES OF THE GEOLOGY OF THE NORTHEASTERN WEST INDIA ISLANDS.

(Abstract.)

Prof. Cleve's paper contained a resumé of his observations made during 1868–9, in and around the Virgin Islands, and published in the Swedish language in the *Trans. R. Acad. Sci.* of Stockholm, in 1871. He regards the whole group as of Cretaceous and Tertiary age, with the exception of Anegada, which, like the Bahamas, is post-pliocene.

The strike of the rocks, and the trend of the entire group, are approximately east and west. The rocks are various, largely eruptive and metamorphic. Of these, Prof. Cleve discussed somewhat fully the character and distribution of the following kinds:—1, Diorite; 2, Felsite; 3, "Blue-beach" (a peculiar volcanic breccia, locally so-called); 4, Diabase.

All these rocks have great thickness, and indicate long-continued volcanic activity. As in modern lavas, they present two types, basic and acidic.

Metamorphic slates are next described; and then a partly metamorphic limestone, occasionally with recognizable fossils, sufficient to fix the age as certainly Cretaceous.

Santa Cruz Island is then described, and referred to the same series as the Virgin group. All these islands thus indicate, by their east and west strike, and the great upturning of their rocks, that they were formed by a north and south pressure, forcing the Cretaceous and associated volcanic beds into a great line of anticlinal and synclinal folds. This period seems to have been about that of the white chalk; but the force continued to act during the succeeding Eocene time, though with diminishing intensity, as is shown by the less inclination of the Eocene beds. The Miocene strata are little disturbed, and the force would therefore seem to have spent itself by that period.

Prof. Cleve then refers briefly to the occurrence of similar metamorphic and volcanic rocks in the interior of the Great Antilles, and regards the entire series as having been formed by the same general movement of Cretaceous folding, the Virgin Islands forming the eastern extension of the line of elevation.

The Eocene strata are then taken up and discussed, as they occur in the islands of St. Martin and St. Bartholomew, just east of the Virgin group. Professor Cleve regards these islands as wholly of Eocene age, claiming that the eruptive rocks of which they mainly consist, are *interstratified* with the limestones, which contain fossils of the age of the Calcaire Grossier, of the Eocene of Paris. He then traces the occurrence of Eocene strata in Antigua, Guadaloupe, parts of Trinidad, and largely in Jamaica; and re-affirms his conclusion that the movement which raised the Great Antilles and the Virgin islands continued during the early Tertiary, though with lessening force.

The Miocene formation is then considered. It forms the small island of Anguilla, and occurs on several of the islands, south to Trinidad; but has immense development in the Great Antilles. It is chiefly a limestone series, is generally little altered from a horizontal position, and at times may be seen resting uncomformably on the Eocene. By this time, evidently, the disturbing movements had ceased to make themselves felt.

The later Tertiary rocks, Pliocene and Post-pliocene, have not been very clearly marked off from each other or from the Miocene. But to the Post-pliocene period are referred the Bahamas, Anegada, and the remarkable series of volcanic outbreaks that characterize the islands of Saba, St. Eustatius, St. Kitts, Nevis, Monserrat, Guadaloupe, &c. On St. Kitts, Prof. Cleve describes a limestone with over forty species of fossil shells, all but one of which are identified with living species of the Caribbean sea. The same is true of Anegada.

The elevation of the Miocene strata of the Great Antilles took place apparently by a "continental" uplift, whereby large areas of marine deposit were raised without folding or disturbance. Professor Cleve suggests that this movement may have been accompanied by a sinking of part of the sea-bottom in the Caribbean region to the south-east, and that on the limit between the areas of rise and of depression, fissures and faults may have occurred, through which these volcanic outbreaks of the Leeward islands found exit, in the Post-pliocene time.

DISCUSSION.

Mr. A. A. Julien confirmed the accuracy of these petrographical distinctions of the rocks of the Lesser Antilles, from the results of observation during a residence of four years on Sombrero and vicinity. The island of St. Eustatia consists mainly of volcanic ashes in a thick tabular and horizontal stratum with vertical faces along its coast. This is flanked on the south end by a volcanic cone with extinct crater, of which the bottom is occupied by a plantain plantation, but the sides are bare, and consist of a dark basaltic rock; and on the north end by two lower cones, not visited but probably volcanic. On the island of Saba the rock is light colored, rich in crystals of sanidine, and apparently a trachyte, constituting a remarkably sharp volcanic cone, with its sides deeply furrowed from top to bottom by eroded ravines; certain depressions upon the summit, resembling craters, present in some localities sulphur deposits which have been found of commercial importance.

However, the conclusion of Prof. Cleve, as to the recent age and eruptive character of most of the crystalline rocks of this region, appeared surprising in view of their metamorphic associates, and of their similarity to those of the Archæan areas identified by Hartt in Brazil. It was a question whether a nucleus of Archæan, or, at latest, metamorphic pre-Silurian rocks, in general highly tilted, does not form the axis of such islands as St. Martin, St. Barts, etc.

Prof. D. S. Martin questioned whether a corresponding movement of disturbance should not be also found in the Cretaceous strata of a region no farther removed than that of the vicinity of our own Gulf coast.

Dr. J. S. Newberry remarked that the importance of the subject of the age and origin of these crystalline rocks still demanded their re-examination and a review of Prof. Cleve's conclusions by some worker of experience in this peculiar field. One of the most interesting topographical features on this continent consisted in the line or axis of elevation marked by the Windward Islands, separating the deep basin of the Gulf of Mexico on the one side from the abyss of the Atlantic Ocean on the other. It presents a prolongation and connection of the mountain chains which run along the eastern border of the North and South American continents, in a course imperfectly parallel to that on the western border of these continents, with the gulf lying enclosed between these two great ranges. This axis has been the scene of violent volcanic action and has been supposed to mark the place of that mythical area of sunken land, styled Atlantis by the ancients. The tradition long current, recorded by Herodotus and others, points to a densely populated land west of Europe, covered with cities, and threatening the civilization of the Eastern hemisphere, which was punished by the gods by being sunk beneath the sea. According to the recent observations of an

English geologist, Mr. Thomas Belt, this legend may have had some foundation in the former existence of a continent, now submerged beneath the Caribbean sea, through which the peaks represented by the Lesser Antilles, constituted a mountain chain. Local disturbances have certainly affected this area, but we fail to find any evidence of corresponding disturbance in the Cretaceous strata of our southern States, except perhaps in continental elevations and depressions. Messrs. Guppy, Gabb, and others have studied the rocks of the region, but, up to this time, no one trained to the examination of the difficult phenomena and problems under discussion.

NOV. 14, 1881.

The President, Dr. J. S. Newberry, in the chair. Twenty-four persons present.

A paper was read by Dr. Alexis A. Julien on

THE EXCAVATION OF THE BED OF THE KAATERSKILL, N. Y.

(ABSTRACT.)

This paper was supplementary to one read before the Academy two years ago, concerning the phenomena of erosion, glaciation, etc., in the Catskill Mountains, in the vicinity of the Kaaterskill Clove.

Flexure of Strata.—Prof. James Hall has indicated the existence of four lines of flexure, running from N.E. to S.W., the synclinals occupying the summits of ranges, and Prof. Arnold Guyot locates one of these at Slide Mt. The dips at the entrance of the Clove vary from 8° to 10° to the W. N.W., becoming only 3° four miles to the westward, *i. e.*, more nearly horizontal towards a shallow synclinal fold supposed to occupy Hunter Mt.

One of the most interesting discoveries of Guyot was the linear series of three maxima of altitudes above 4000 feet, Slide Mt., Hunter Mt. and Black Dome. The gentle flexure of the whole stratum required to produce this line of maxima may be thus shown in the range running S.E. and N.W. through Hunter Mt., 35 miles long. Toward the S.E., the descent from the crest of Hunter Mt. (Alt., 4038 feet), to Overlook Mt. (3150 feet), is 888 feet, in 9½ miles, equivalent to 1 in 56, or about 1°; toward the N.W., from Hunter Mt. to Utsyanthe Mt. (3203 feet) the descent is 835 feet in 25 miles, equivalent to 1 in 158, or less than ½°.

Another similar series of maxima, however, occurs further to the westward, consisting of Graham Mt. (3886 feet), Bear-pen Mt. (3545 feet), and Ashland Pinnacle (3420 feet), distant respectively 9, 12, and 15 miles westward of the former series. This southward convergence of the axes of these two folds may probably account for the increased protuberance and greater elevations in the Southern Catskills.

Newly determined altitudes.—Many new determinations have been made of points in the vicinity of the Clove by means of an excellent aneroid, with constant reference to the numerous stations in the vicinity whose altitudes have been accurately obtained by Guyot. A few are here subjoined:

	Feet.
Hotel Kaaterskill, on South Mt.	2466
Parker Hill, summit	2565
Parker Mt., "high ledge."	2874
Clifton House	2101
Newman's ledge, on North Mt.	2486
Gap between E. and W. peaks, North Mt.	3116
Toll-gate on Mt. House road	760

Glaciation of summits.—All the crests near the Clove have been now examined. On none above an altitude of 2900 feet have glacial striæ been found, in part because they consist of thinly laminated flags deeply disintegrated by frosts. The highest striæ discovered were found on Parker Mt., "High ledge" (2874 feet), running S. 18° W. (magnetic), and under the roots of a large tree on the SE. slope of Round Top, at an elevation of 2871 feet, running S. 35° E. However, in all cases, a marked difference exists in the slope of different sides of a peak, the E. and S.E. sides presenting a precipitous face, and the other sides more or less of a gentle slope.

The highest striæ yet found in the Catskills occur on Overlook Mt., at an elevation of about 3100 feet, implying a depth of ice in the Hudson river glacier of about or at least 3200 feet. Within the Kaaterskill basin, several miles distant from the Hudson valley, the overflowing ice stream became shallower, having an altitude of about 3000 feet. It thus appears that the surface of the glacier inclined westward over these mountains, with a slope of 200 feet in 3 miles, 1 in 84, say about ½°.

The conclusions of the former paper have been confirmed by recent observation, viz., that two glacier streams have swept over these mountains, the Continental Glacier from the N. W., submerging and carving out the highest peaks, and the Hudson Valley Glacier from the N., later, more shallow, bearing along vast quantities of materials derived from the crystalline and lower Silurian rocks of the Adirondacks and of the Helderberg Mts., and strewing the whole region with their boulders; and that no local glaciers have existed in the Catskills after the retreat of the Hudson Valley Glacier.

Tilting of the Catskill plateau.—In the previous paper an explanation had been given of certain facts which seemed to indicate that the whole formation had been gently inclined to the East and then to the South-east, before assuming its present W. N. W. inclination, at a period far anterior to the Glacial epoch. A profile section of the ancient Kaaterskill valley, was exhibited, reaching from Haines' Falls nearly to the junction of the N. and S. branches of Schoharie creek, proving the gentleness of the slope, the absence of rock, and the existence of a deep and narrow buried cañon, now filled up with moraine material and a capping of peat.

A comparison of the altitudes of Prattsville (1164 ft.), a point on the Western axis, 12 miles distant from the Kaaterskill Clove, and of the lip of the stratum above Haines' Falls, (1857 ft.), at the head of the Clove, shows that a depression of the latter point below a line connecting these two points, even to the extent of a single degree, would cause a descent of nearly 700 feet from Prattsville to Haines' Falls, *i. e.*, toward the East. The excavation of the deep Kaaterskill and Plaaterkill Cloves could hardly have been effected by the small streams now occupying their beds. It is more probable that the Schoharie creek formerly flowed, at a higher level, to the east into the Kaaterskill Clove, and afterwards to the south-east into the Plaaterkill Clove, before the latest tilting of the plateau to the W. N. W. caused a reversal of the flow of the stream, in the very opposite direction, through the greater part of the same valley. An objection to this theory presented itself in the obstacle which has created a turn to the S. W. in the North branch of Schoharie creek, near its junction with the South branch. But on recent examination this was found to consist not of rock but of a huge mass of coarse moraine material deposited during the Glacial period on the southern slope of the Schoharie valley.

Sculpture of the plateau.—In a terrane consisting of strata which dip at varying and perhaps very high angles, the carving out of ranges and production of ravines and gaps may generally be assigned to the occurrence of flexures, of dykes or faults, or of beds whose material is unusually soft, fragile, or rich in minerals of easy decomposition. But the problem of topographical sculpture is less easily solved in a stratum like that of the Catskills consisting of a regular succession of layers which are horizontally homogeneous and from which the phenomena of disruption are absent. The original disintegration and erosion of the mass which resulted in the production of the ranges was perhaps mainly influenced by the direction of the jointage. With this the trend of the ranges in the vicinity of the Kaaterskill Clove appears to